these walls were drawn out by the diminished pressure caused by the southwest wind blowing along the roof and side of the house.

The steeple of the New York avenue Presbyterian Church was blown down and appeared almost as if it had been picked up, turned upside down, and dashed down on its point. In the country about Washington there were two streaks of destruction that were well marked. One of them was about 2 miles beyond Cabin John Bridge on the Conduit road, and the other near the Tennallytown pike. A careful search along Seventh street and the Chevy Chase road showed very slight action. On either side of Fourteenth street, however, there was serious destruction to trees and roofs. The official estimate of the total loss to structures throughout the whole city puts it at $400,000.

(*b*) ALEXANDRIA, VA.

It was commonly reported that the worst destruction had occurred at Alexandria, but the facts do not bear out this assertion. There was no tornado track or even the semblance of one. The wind carried the roofs that were blown off a little farther than in Washington, and the unroofing of houses and factories along the river front was quite serious, but aside from this there was little serious destruction.

A church at the corner of Princess and Patrick streets had its roof crushed in, but singularly enough, the tower, which was much taller than the church, was not injured in the least. There was every evidence that the southeast wind struck the east roof of the building (whose ridge pole stretched north and south) and crushed it in because of a great weakness in the timbers supporting the roof.

Every place was visited by me where inquiry showed a visitation of the wind rush. The estimated loss to structures was greatly exaggerated. Four lives were lost. In one case the west brick wall of a 3-story house was drawn out by the wind and crushed through the roof of a lower neighboring house, killing a man in the top story. The streakiness of the wind was far more marked in Alexandria than in Washington, and it was found possible to follow these streaks over much greater distances.

KITE EXPERIMENTS AT THE BLUE HILL METEOROLOGICAL OBSERVATORY.

By S. P. FERGUSSON (dated August 26, 1896).

Kites were first employed at Blue Hill Observatory in observations of atmospheric electricity, by Mr. Alexander McAdie, in the summer of 1885. The kites used were coated with tin foil, and served as collectors; the current passed down a copper wire to the electrometer at the ground. No high flights were attempted. These experiments were repeated by Mr. McAdie in June, 1891, and July, 1892.

In July and August, 1894, Mr. William A. Eddy, of New York, who had been very successful in reaching great altitudes with kites of the so-called "Malay" type, spent two weeks at Blue Hill for the purpose of employing the kites designed by him in meteorological observations. It became very evident after a few days of experimenting that the Eddy kites could be utilized to elevate self-recording instruments, and on August 3 an ordinary Richard thermograph was altered for use in the experiments. The heavy parts were replaced by wood and aluminum, and the modified instrument, with a small basket inverted over it to serve as a screen for the bulb, weighed altogether 2 pounds and 5 ounces. On August 4, 1894, this instrument was twice elevated to a maximum height of 1,430 feet (the height being determined from angles taken at the ends of a 300-foot base line), and an excellent temperature record was obtained. Five Eddy kites, having a total area of about 100 square feet, were employed. This is believed to be the first use of kites for elevating self-recording instruments. The first experiment was repeated with equal success on August 15. A detailed account of the two ascensions, prepared by Mr. Clayton, appeared in the American Meteorological Journal for December, 1894; details of the kites and thermograph were also published in the Scientific American for September 15, 1894.

The experiments were resumed in June, 1895, and since then have been made, under the direction of Mr A. Lawrence Rotch, by Mr. Clayton, Mr. Sweetland, and the writer. Before any ascensions were attempted careful tests of materials for kites and line were made, and a windlass constructed. By the 23d of July a number of serviceable kites were ready and observations were recommenced on that date. Early in August a baro-thermograph, similar to the first instrument, and weighing 2 pounds, was constructed and observations begun with the new instrument. The first Hargrave kite made at the Observatory was flown on August 18, 1895. Mr. Eddy returned on August 17, and remained until September 6, experimenting with kites and making photographs from the kites at elevations of a few hundred feet. Ascensions with the baro-thermograph to an average altitude of about 1,200 feet were also made almost daily during this time. The maximum height reached was 1,916 feet on August 28, with 3,500 feet of line and seven kites. An improved Hargrave kite was first used for lifting the baro-thermograph on September 21, an altitude of 1,600 feet being reached. The baro-thermograph was lost on September 22, 1895, and no further experiments except in improving the kites (both Eddy and Hargrave patterns) were made until November 16. By that time a new instrument, for recording wind velocity and temperature, had been constructed, and was used for the first time on that date; this was probably the first recording anemometer elevated by kites. Ascensions to heights of 1,000 to 1,500 feet were made about twice in each week after that date.

On January 27, 1896, steel music wire was substituted for cord as a main line, and proving to be greatly superior to cord was afterward used exclusively.

During the winter of 1895–96, some records were obtained during rain and snowstorms by using kites, rendered waterproof by varnish. On March 11, 1896, an ascension was made during a severe northeast gale. The recording instrument elevated by two Hargrave kites disappeared in the clouds at a height of 2,000 feet. An altitude of about 3,300 feet was reached, but the instrument was clogged with frostwork and snow, and the record was lost after the clouds were reached. On April 4 a meteorograph, recording pressures by aneroid, as also temperature and humidity, was received from Richard Brothers of Paris, and its use begun. An altitude of 3,964 feet above the hill was attained with this instrument on April 13.

In July, 1896, at the suggestion of Mr. Douglas Archibald, of England, a tail made of cloth cones was attached to one of the Eddy kites, greatly improving its stability.

On July 20 the height of a mile above the hill was reached for the first time, and on August 1, 6,703 feet, the maximum elevation attained so far.

The method followed has been to conduct experiments with the recording instruments in connection with the tests of materials and different forms of kites, as in this way it was found possible to adapt the kites to the work required of them more readily and thoroughly than by perfecting one department of the investigation before beginning the other. Except when the altitude of clouds was measured, the recording instrument was sent up during every ascension with the tandem line, and in this way the most economical use of the kites was made.

During the first eight months the cord used for a main line was what is known as "blocking cord,"—a hard-twisted linen line resembling the cable-laid twines, the tensile strength of which varied with the different sizes from No. 9, 80 pounds, to No. 32, 300 pounds. Nos. 12, 16, and 32, were used in about equal lengths in the line of 3,700 feet that was in use from June, 1895, to January, 1896. This cord was selected from a great variety of lines tested both for maximum strength with minimum weight and size and for durability, for it was found during the tests that many of the cords that were light in proportion to their strength were not sufficiently durable for continued use. Among cords of this class are flax sole thread (the lightest for its strength of all that were tested) and several varieties of braided lines. The cords were tested in 25-foot lengths, a few tests of this length giving a better average of the strength of the line than many tests of shorter pieces. The durability tests were very important, as very few cords after being once strained to the limit of their strength could withstand the same strain a second time. The loss of strength in the braided lines and shoe-sole thread was considerable, amounting in some cases to 30 per cent, while in the blocking cord and cable-laid twines it rarely exceeded 5 per cent. Frequent tests of the cords in use were found necessary, and to be secure against breaks the average strain upon the line was not allowed to exceed one-third of the breaking strain.

The tests of knots were limited to those that seemed likely to be useful. The "surgeon's" or "fisherman's" knot for uniting lines, the "square knot" for tying joints in kite frames, etc., and the "bowline knot," were obviously so much better for the purposes named than all other knots that no others were tested. Knots were dispensed with whenever possible, as the cords were not durable when tied and retied many times, and in time the surgeon's knot came to be almost the only knot used. As a substitute for knots in attaching secondary kites to the line, a device of Mr. J. B. Millet's was adopted almost at the beginning of the experiments. This device is shown in Figs. 1 and 2. An eyelet is secured to the line by means of two simple loops which are readily loosened after sustaining a continued strain. The secondary or leading line extending to the kite may be attached by the bowline knot, or still better, by a simple toggle made of aluminum. This eyelet and toggle constitutes by far the simplest method of attaching secondary lines to the main line whether the latter be of cord or wire, although in the case of wire great care is necessary to avoid kinking when the eyelet is attached or detached.

During the experiments it very soon became apparent that heights exceeding 2,000 feet would be extremely difficult to reach if cord alone were used for a line. The weight of the cord proved to be of slight consequence compared with the surface exposed to the wind, and the angular elevation of the meteorograph in high winds, as observed from the reel or drum, was, as a rule, less than 35° for heights averaging less than 1,500 feet. Pianoforte, or music wire No. 14 gauge, 0.0326 inch in diameter, tensile strength 300 pounds, and weighing 15 pounds to each mile of length, was finally adopted for the main line. This wire is obtainable in lengths of 7,000 feet or more without splice or break, and, as a main line, has proved far superior to cord. Three and even two kites now attain greater altitudes than did six to ten kites when held by cord, and the average angular altitude of the self recording instrument has increased to nearly 40° even at elevations approximating one mile. The only weak points in the wire are the splices and connections to which the kite lines are secured. The telegraph splice alone, as Professor Marvin points out in MONTHLY WEATHER REVIEW, May, 1896, is objectionable, though when carefully made it answers very well for light strains. The Marvin splice is much better, and probably a combination of the two—a Marvin splice finished at each end with a telegraph coil and this covered with annealed wire—is best of all for durability. In this form of splice, when the end of the wire (after the Marvin splice is complete) is wound tightly around the main wire, the tendency of the twist to straighten and gradually become loose is avoided. The splices should not be less than 6 inches long, and 10 inches is a safe length. A durable splice is better than one which may be strong enough to resist ordinary tests but which weakens through use; and the combination splice referred to is recommended as both strong and durable, it having been thoroughly tested.

For securing the secondary lines to the wire, a form of clamp devised by the writer has been found very satisfactory. As shown in Fig. 3, it consists of an angular aluminum casting with the ends slotted to receive the wire, to which it is clamped by screws. The secondary line is tied in the usual manner in the hole at the junction of the two ends, which is located nearer the short arm of the casting. The clamp is always secured with the short arm toward the kites in order that the strain of the secondary kite may come nearly equally upon the two arms and the danger of permanent bends in the wire avoided. No instance of permanent bending of the wire has occurred during many experiments with this clamp, and from two to six have been used during every ascension for several months; nor has a clamp slipped or become loose when properly made and attached. The only objection that may be made to its use is that some time is necessary to attach it and tighten the two screws. The advantages of such a portable clamp are that it may be applied wherever kites are needed to take up the sagging of the wire, and that all injury to the main wire likely to occur from winding it over permanent connections while under strain is avoided. It has been found that while no injury is caused by winding the wire over loops and splices while the tension is slight, small irregularities in the surface of the drum are sufficient to cause slight permanent bends when the strain is great—from 90 to 150 pounds or more.

The windlass used is similar to the ordinary hoisting windlass and is mounted upon substantial wheels, so that it can be easily moved from place to place. The spool or drum containing the wire is of hard wood. The center of the spool is 6 inches in diameter, and the heads 10 inches in diameter and 1 inch thick. Outside the heads are flanges 10 inches in diameter and one-half inch thick, and these are held in place by three one-half inch bolts passing lengthwise through the drum near its circumference. This spool or drum is operated by two opposite cranks of 8 inches radius. Longer cranks were tried, but the labor of winding in the wire with them was found more exhausting than with short cranks, and the work generally not so satisfactory. A gear of two to one was tried also, but was not so effective as direct cranks.

To the windlass is attached a register for indicating the length of wire used. The wire passes under a hardwood pulley exactly half a meter in circumference, which, with the registering dials, moves freely backward and forward upon its supporting shaft, which is parallel with the axis of the reel, and thus is self-adjusting to any change in position of the wire. Careful tests of this register show it to be very accurate, the greatest differences between letting out and reeling in 3,400 meters of wire not having exceeded 10 meters, and the length of the wire is obtained directly without the necessity of applying any reduction factor.

In computing the altitude of the kite meteorograph the following formula is used:

$$H = l \sin. h,$$

in which H = the height of the instrument above ground, l = the length of the line, and h = angular height of instrument above the horizon. The angular heights are measured by means of a transit located at the windlass, and the length of the line is determined from readings of the register already described. Repeated comparisons of heights obtained by this method with measures obtained from theodolites at the ends of a base of 1,178 meters, show a mean difference of + 2 per cent and maximum difference of + 5 per cent, this including all errors of triangulation, sagging of the line, and instrumental errors. It is believed that after subtracting 2 per cent to allow for sagging of the line the accuracy of the first method is at least equal to that of the second, and on account of its great simplicity it is to be preferred. One observer can make the readings of the transit and reduce the observations as they are entered.

Much time has been spent in testing materials for kites. For frames, both umbrella ribs and wood have been tried, and of these straight-grained spruce has been found to be the best. For "stringing" the frames and joining the several sticks, several varieties of wire, cord, clamps, and joints have been tested. Picture wire and cord that has been well stretched (old kite line is good) are excellent for stringing the frame, but when an adjustable frame or a detachable cover is desired cord is much better than the picture wire. Metallic clamps and joints, while serviceable in the construction of light kites were not found to be durable and were continually coming loose. The best method of securing the frame of a kite is to tie the parts with well stretched cord and coat the joint with glue. When varnished or painted these joints remain tight. The frames of one or two of the first kites were secured with nails, but these weakened the sticks and in time became loose.

For covering frames, bond tracing paper, fine nainsook, or silk were found to be the strongest and most durable materials for their weight. Lonsdale cambric and percaline are slightly less expensive than nainsook, but are much heavier and no stronger. Manilla paper is cheaper but not so strong as the bond paper and is twice as heavy for the same strength; hence it can not be recommended. Cloth is preferable to paper for kite covers, unless extreme lightness is desired, as, when suitably varnished, cloth-covered kites may be flown in rainstorms and into clouds without injury.

The kites used are of the Eddy or Malay and Hargrave or cellular type, although others have been tested, and these have given excellent results. To some extent the two forms of kites supplement each other, and it has been customary to fly both on the same tandem line. The Eddy kite usually flies in lighter winds than the Hargrave and at a higher angle—with a short line, from 50° to 70°—but it is not so stable as the Hargrave. The Hargrave is very stable and is better adapted to use in high winds, but its angular height is comparatively low—40° to 60°—and its structure more complicated than that of the Eddy. Experiments have been directed, therefore, toward improving the stability and rigidity of the Eddy kite and the angular height attained by the Hargrave. Greater strength and rigidity of frame, without appreciable increase of weight, is obtained by securing together two flat sticks of, say, $\frac{3}{8}$ by $\frac{1}{8}$ inch cross section in the form of a T rail, by coating the surfaces to be joined with glue and tying them together with cord. Varnish or paint renders the joint waterproof. In constructing Eddy kites for use in high winds the dihedral angle has been substituted for the usual bow with better results. A very simple method of constructing this angle joint is shown in Figs. 4 and 5. *B* is a short piece of square tubing, one side of which is slotted to receive the upright stick, *A*. The ends of the pieces forming the cross stick, *D D*, are driven into the open ends of the tubing, which is then bent at the slot to the desired angle, as in Fig. 5. When this is done the jaws of the slot hold the upright stick firmly, and usually no wrapping with cord is necessary to keep the joint tight. A piece of wood, *E*, shaped to fit the angle, is then lashed firmly to the cross sticks, which may be further strengthened by means of a second brace, *F*. An advantage of this construction is that if one stick is damaged, it may be replaced without disturbing the others. All joints are coated with glue and varnish. Several kites made in this way have been in use during a number of ascensions with excellent results, and the joints have remained secure. The cover of the Eddy kite is made up separately and tied to the frame afterward. This method has proved most satisfactory. A diagram of the kite is drawn upon a suitable table or board and a screw placed at each corner of the diagram with its head projecting about $\frac{1}{4}$ inch above the surface. The frame once prepared in this manner will do for any number of kites of the size adopted as the standard. The cloth is stretched over the board and tacked outside the edge of the diagram representing the kite, and the screws forced up through it. The cord to go in the edge of the kite is now passed outside the screws and tied at the screw at the top of the kite, a knot being also made just below each of the side corners, to prevent the ends of the cross stick from slipping down. The cover is pasted over the cord, except at the corners, the paste being rubbed in thoroughly and a smooth seam made. The whole should not be disturbed until thoroughly dry. Drying may be hastened by ironing the seams. The cover, when completed, is tied to the frame; the short sections of the binding cord exposed at the corners are passed over grooves cut in the ends of the sticks. The knots below the side corners are firmly secured against the lower edges of the sticks and the joint coated with glue, to prevent slipping, as these are the places where slipping of the cover and looseness cause distortion of the kite while it is in the air. The cloth of the cover is also firmly lashed over the corners, except at the top of the kite. At this point the ends of the cord, which are left bare for a few inches, are simply tied together with a square bowknot and placed in a groove in the top of the vertical stick. This is to provide for adjustment of the tension of the cover, which, as the kite is used, becomes loose, unless the cloth is well stretched previously, and requires occasional tightening. To make the kite wind proof and waterproof, it should be well varnished. A solution of rubber in bisulphide of carbon and turpentine has been used by Dr. Stanton with excellent results; also the following mixture has been successfully tried at Blue Hill:

Pure rubber (shredded)......1 ounce.
Bisulphide carbon.....2 or 3 pounds.

Add 2 or 3 pounds of this mixture to 1 pound of spar varnish and thin with turpentine. It is best to apply a small quantity at a time, as two or more thin coatings are necessary in most cases. Thick varnish with only a small percentage of rubber appears to rot the cloth or render it brittle, and it is best to use from two to three times as much rubber solution as varnish. But few tests of varnishes have been made, and further experiments are necessary to obtain a varnish fully adapted to coating kites.

Greater stability in the Eddy kite is secured by the use of Archibald's cone tail, which consists of two or more cloth cones placed open end up at intervals of 3 to 6 feet, upon a string attached to the lower end of the kite, the last cone being from 3 to 8 times the length of the kite below it. The cones are usually 5 to 8 inches in diameter and 7 to 15 inches in length, and are kept open at the base by a ring of aluminum wire to which the cloth is sewed or pasted. The ratio of the wind pressure upon the cones to that upon the kites appears to be nearly constant at ordinary velocities, and as the balancing of the kite is dependent upon the pressure of the wind instead of the weight of the tail, the kite will fly steadily through a greater range of velocity than if no tail were used. A serious objection to the tail is its liability to become entangled in the other lines, but this is partially remedied by using longer secondary lines than are necessary for tailless kites. Except for this defect the combination of the Eddy kite and Archibald cone tail appears to be better adapted to meteorological work than any kite we have tried, as its angular height is greater than that of the Hargrave kite, and its stability very little inferior to it, while the structure is much less complicated. Further experiment, however, is necessary to fully establish this.

The experiments with the Hargrave kite have been conducted almost entirely by Mr. Clayton, who has greatly simplified and lightened the original kite and otherwise improved it. The number of sticks necessary has been reduced to ten and the coverings are laced over the frame, thus rendering the kite adjustable. Rigidity in the frame is secured by using angular pieces of aluminum at the joints, which are bolted or firmly lashed to the sticks. The first kite frame was joined with nails but the sticks split and broke at the points where nails were placed, and this method of fastening the sticks was abandoned. It was found best not to cut or alter the form of sticks, especially when they were subjected to strains in one direction only. The best kites of the new design have flown steadily in all winds, remaining in the air until wrecked without showing a tendency to dive. The range of velocity for these kites is usually between 15 and 35 miles an hour, though the best kites have flown in winds of from 12 to 42 miles.

The recording instruments used are of the Richard type and are constructed as light and rigid as possible. The first two instruments were simple modifications of ordinary thermographs and barographs and need no description. The records were made upon one clock cylinder and the mechanisms were protected from direct sunlight, etc., by a light basket hung over the instrument. A long spring forming part of the suspension cord served to check vibrations caused by the kites. The third instrument or thermo-anemograph, constructed in November, 1895, was encased in an aluminum box instead of a basket and was adapted for observations in rainy and cloudy weather. The thermograph bulb was made at the Observatory and is not so sensitive as the ordinary thermograph, but is sufficiently accurate for good observations. The anemometer is exactly one-half the size of the U. S. Weather Bureau instrument and the cups are suspended below the instrument. The cups and spindle are supported by a ball bearing which reduces friction to a minimum. Each mile of wind is marked upon the record cylinder. The method of suspending the instrument so that its position will be nearly vertical at all times is shown in Fig. 6. The heavy parts are placed near one end and the center of support is also near the heavy end. A fan or sail of sheet aluminum, *A*, extends upward from the rear of the instrument and is equal in area to the end of the instrument below the point of suspension, so that when the instrument is blown backward by high winds its position is still upright and the heavy end still in front. Frequent comparisons of the instrument while suspended near the Observatory, with the standard anemometers, showed differences of only 2 per cent, and no correction for verticality appears to be necessary. The speed of the cylinder that carries the record sheet is $1\frac{3}{4}$ inches per hour and the total weight of the instrument $2\frac{1}{2}$ pounds. The three instruments just described were designed and constructed at the observatory by the writer. The fourth and last instrument was obtained from Richard Brothers, of Paris. It records heights by aneroid, and also records humidity and temperature; its weight is $2\frac{3}{4}$ pounds. The mechanism is protected by a wire cage which does not shelter the thermograph bulb from sunlight, and suitable screens were attached after it was received. All these instruments have been used with success. The principal difficulty met has been that of obtaining good ventilation for the thermograph. Aspiration apparatus is practically impossible and the best shelter appears to be a light wooden basket inverted over the instrument. It is necessary to allow no metal parts exposed to direct sunlight to come in contact with the air that passes the bulb. The screens used with the Richard instrument were devised by Mr. Clayton and are made of varnished cloth; both sides and top are double with an air space between the two walls. This form of screen appears to give good results as shown by comparison with the thermometers in the Hazen shelter and an Assmann aspiration thermometer. Since neither thermometers in the shelter nor aspiration thermometer give true air temperatures at all times the ventilation of the kite thermograph may need to be improved, though in a fresh breeze it appears to be as good as that afforded by the standard shelter of the Weather Bureau. Experiments with screens are being made, however, and a meteorograph is being constructed, in which it is hoped that the defects of the instruments now in use will not appear.

Before the instrument is attached to the kite line it is suspended some distance above the ground for comparison with the standard instruments during a space of from five to twenty minutes. Two kites are secured by lines of 100 to 150 feet in length to the ring or eyelet in the end of the wire, and when these are in the air the instrument is suspended from the same ring by about ten feet of cord. The area of the kites placed at the top of the line depends upon the pressure of the wind, a strain of 20 to 50 pounds upon the wire being sufficient to lift the meteorograph at a good angle. In high winds two kites of not over 15 square feet each are sufficient, and in light winds an area of 20 to 30 square feet for each kite is necessary. From 1,000 to 2,500 feet can then be paid out before a third kite is necessary. The difference in angle between the meteorograph and the wire at the windlass is not usually allowed to exceed 5° before an additional kite is attached. Stops of from three to fifteen minutes are made after each 500 meters of line to obtain records at these points, ascending and descending, and observations, both of the azimuth and angular height of the meteorograph, are made each minute. Intermediate altitudes are determined from the barograph. After the meteorograph is brought back to the ground it is again compared with the standard instruments before the sheets are removed. It is almost impossible to prevent the jerking of the kites from affecting the recording pens, as the pens are disturbed frequently when the kites, to all appearances, are flying with great steadiness; hence frequent comparisons with standard instruments are made to determine corrections. Ascensions have been made in winds averaging from 10 to 40 miles an hour at the ground. The greatest altitudes have been reached in winds of moderate velocity. Since the adoption of music wire for the main line the time and labor of making ascensions has been greatly shortened, and it is now possible to reach altitudes of 1 mile with less fatigue and in less time than was formerly necessary to reach altitudes of 2,000 feet or less. The average height of 22 ascensions made previous to November 30, 1895, was 1,140 feet. This is only about 100 feet lower than the average height of 23 ascensions of the captive balloon employed in the Berlin experiments of 1891–1893. Since January, 1896, the average and extreme heights for the maximum amount of line are as follows:

Length of line.	Mean height.	Maximum height.	Minimum height.
Feet.	*Feet.*	*Feet.*	*Feet.*
2,050	960	1,370	440
6,300	2,220	3,964	375
11,250	4,500	6,703	714

The length of wire used from January to March was 2,050 feet; from March to July, 6,300 feet; and since July 1, 11,250 feet. Hence, if the average heights obtained with cord are to be compared with those obtained with wire, it is necessary to consider the length of line used. The entire length of the wire or cord was not used in all the ascensions, and the differences between the heights given and the length of wire should not be understood to imply that the angular heights were low. Altitudes approximating 1 mile were reached on July 20, 22, 23, and August 1, 1896, and none of these ascensions occupied over six hours. The ascension of July 20 was managed by three men, although the average strain upon the wire was from 80 to 100 pounds, and the maximum, 125 pounds, or nearly 2 pounds for each square foot of kite surface. On July 23 two ascensions of 2,600 and 5,000 feet, respectively, were accomplished between 1 p. m. and 7 p. m., the usual stops at each 500 meters being included in this time.

In the following tables appear some details of two of our highest ascensions which serve to show the method of conducting the ascensions. Observations are made almost every minute, but it was considered unnecessary to include every observation. Stops were made every 300 or 500 meters, or oftener, from 3 to 5 minutes usually, and kites were attached whenever the angle of the wire at the reel was 5° or more lower than that of the instrument. The dimensions of the kites used are as follows:

Designation of Eddy kite.	Length of sticks.		Total weight of kite.	Approximate area.
	Vertical stick.	Cross stick.		
	Inches.	*Inches.*	*Pounds.*	*Sq. ft.*
4-foot	48	48	0.7	7.5
5-foot	60	60	0.9	11.5
6-foot	72	72	1.6	16.5
7-foot	84	84	2.0	22.0
9-foot	108	108	3.7	35.5

Ascension of July 20, 1896.

Time.	Line out.	Pull on line.	Angle of recording instrument.	Corrected maximum altitude of instrument above hill.	Remarks.
	Meters.	*Pounds.*	°	*Meters.*	
9.15 a. m.	0	......	......	0	Instrument left ground supported by one 6-foot and one 9-foot Eddy kite.
9.25-30 a. m.	300	......	47.0-50.0	233	
9.37-40 a. m.	620	......	48.5	456	6-foot Eddy kite attached.
10.29-38 a. m.	900	......	42.7-48.5	660	Upper kites entered base of strato-cumulus cloud; electricity faint; kites occasionally hidden by clouds.
10.43-47 a. m.	1,200	50-125	41.3-46.2	851	
10.51-54 a. m.	1,500	60-85	35.1-37.5	895	
11.02-04 a. m.	2,000	......	36.6-38.0	1,208	
11.13-14 a. m.	2,500	......	38.4-39.2	1,550	
11.26-29 a. m.	3,000	......	31.1-34.2	1,654	Electricity strong.
11.39-51 a. m.	3,430	......	......	......	Kites hidden by clouds.
0.14-19 p. m.	3,030	110	37.7-36.4	1,817	
1.08-10 p. m.	2,000	125	35.3-33.8	1,134	
1.42-50 p. m.	1,400	110	32.7-34.2	769	Kites below clouds.
2.20-23 p. m.	900	......	31.8-34.9	504	
2.34-38 p. m.	610	95	30.0-31.3	311	
2.49-51 p. m.	300	......	34.9-37.2	177	
3.03 p. m.	0	......	......	0	On ground.

Ascension of August 1, 1896.

Time.	Line out.	Pull on line.	Angle of recording instrument.	Corrected maximum altitude of instrument above hill.	Remarks.
2.19 p. m.	0	......	......	0	Left ground; instrument supported by two Eddy kites, one 6-foot and one 9-foot.
2.34-39 p. m.	500	......	25.0-47.0	358	9-foot Eddy kite attached.
2.50-51 p. m.	1,000	100	28.0-30.5	497	
3.02-07 p. m.	1,500	......	45.2-51.5	1,152	Electricity faint; 6-foot Eddy kite attached.
3.20-23 p. m.	2,000	130	30.0-33.3	1,076	
3.50-59 p. m.	2,500	......	33.5-36.5	1,459	6-foot Eddy kite attached.
4.08-18 p. m.	3,000	......	31.0-34.9	1,682	4-foot Eddy kite attached.
4.22-52 p. m.	3,420	100	30.0-37.5	2,043	
5.16-20 p. m.	2,500	......	35.0-35.5	1,425	
5.51-53 p. m.	1,500	......	43.0-44.5	1,030	
6.07-09 p. m.	1,000	......	42.5-44.6	688	
6.26-28 p. m.	500	......	43.9-43.3	340	
6.39 p. m.	0	......	......	0	On ground.

Remarks.—On July 20, the weather was cloudy, the wind from the south and southwest, the mean velocity increasing from 19 miles an hour at 9 a. m., to 33 miles an hour at 3 p. m. Rain began at 3.50 p. m. Maximum temperature of day 74°, minimum 59°.

On August 1, the weather was clear, wind variable before 1 p. m. and very light; the mean velocity at 2 p. m. was 16 miles, and at 6 p. m. 20 miles, varying between 11 and 26 miles an hour during the ascension. The direction from 2 p. m. to 6 p. m. was west and southwest. Maximum temperature 73°, minimum 52°.

The instrumental records of humidity, temperature, and wind velocity are very valuable and interesting. The records at different levels give approximate sections of the upper air, and the changes occurring at different levels can be determined very easily. The directions assumed by the different kites of the tandem also indicate the direction of the wind prevailing at the level of these kites, which in many instances is different from that at the earth's surface. The differences on days when the sea breeze prevails are specially marked, and on one occasion two kites less than 200 feet apart were flying in opposite directions, the lower being sustained by the easterly sea breeze, while the upper was supported by the westerly wind prevailing above the sea breeze. The height and the thickness of the low stratus clouds are easily measured by the tandem line, especially in many instances where the clouds are too uniform to be observed with theodolites. On July 20 the humidity rose from 70 to 100 per cent when the instrument entered the strato-cumulus cloud at 2,070 feet, and afterward at a height of 5,000 feet it fell to 68 per cent or lower, as the dryness was so great that the ink evaporated from the recording pens, showing that the air became very dry above the moist current of air supporting the cloud. The vertical decrease of temperature with elevation is found to be greatest immediately preceding and during cold waves and least before and during warm waves. At elevations between 1,000 and 2,000 feet the wind velocity is about 25 per cent higher than at the summit of Blue Hill.

The results, in detail, of the kite experiments, are being prepared for publication in the Annals of Harvard College Observatory, and the present sketch is intended only to show, to a limited extent, the possibilities of this method of exploring the upper air. It will be seen that the altitudes already reached have been limited in every case by the amount of line employed. With additional length of line and improved apparatus already arranged for and in process of construction, it is safe to predict that altitudes at least twice as great as those already attained will be accomplished.

A HIGH KITE ASCENSION AT BLUE HILL.

By Prof. S. P. FERGUSSON (dated October 9, 1896).

On October 8 the Blue Hill meteorograph was sent up to a height of 9,375 feet above sea level, or 8,740 feet above the summit of Blue Hill, and remained higher than a mile above the hill for three hours. Nine kites, with a total area of about 170 square feet, were used to lift the instrument and the 3 miles of wire; the ascent was completed in about twelve hours, although between 11 a. m. and 1 p. m. the line was drawn down to a height of about 600 feet to remove a defective kite. The ascent from this point was completed in less than ten hours. The record is one of the best we have obtained so far. (The original record is reproduced in fac simile on Chart No. VI.) The altitude scale is much too wide and the correction to the barograph readings at altitudes above 1,600 meters is considerable. The height above given was obtained from angular altitudes observed with a surveyor's transit at the windlass, and has been checked by readings of the barograph. The corrections to the barograph were determined by placing the instrument under an air-pump and

Chart V. Kite Experiments at Blue Hill Observatory.

FIG. 1.

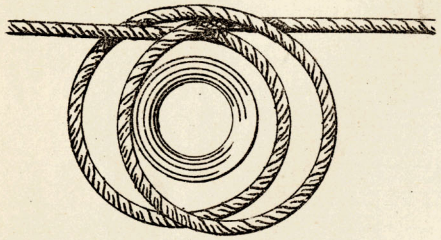

FIG. 2.

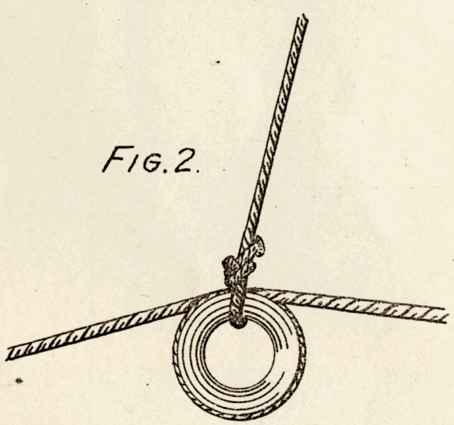

FIG. 3.

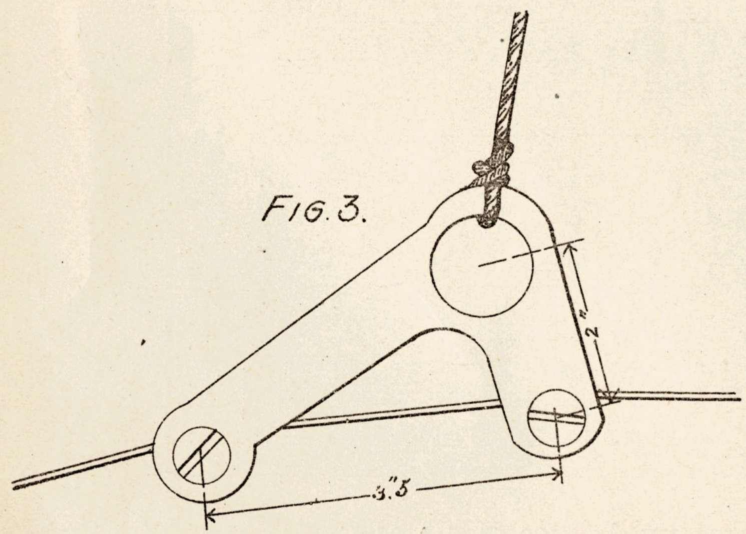

FIG. 5.

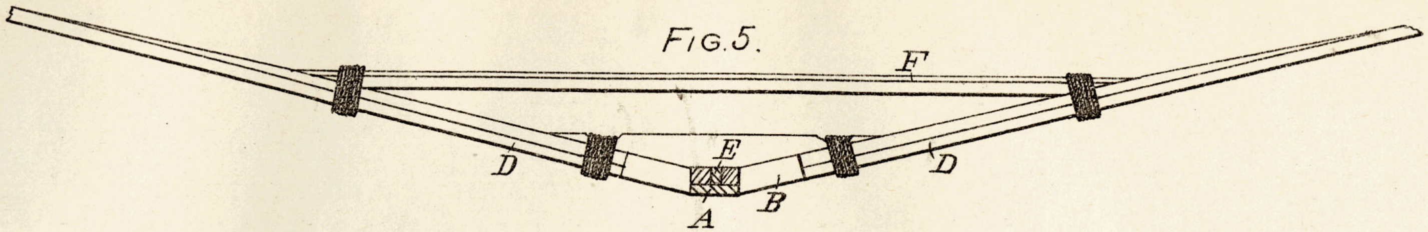

FIG. 4.

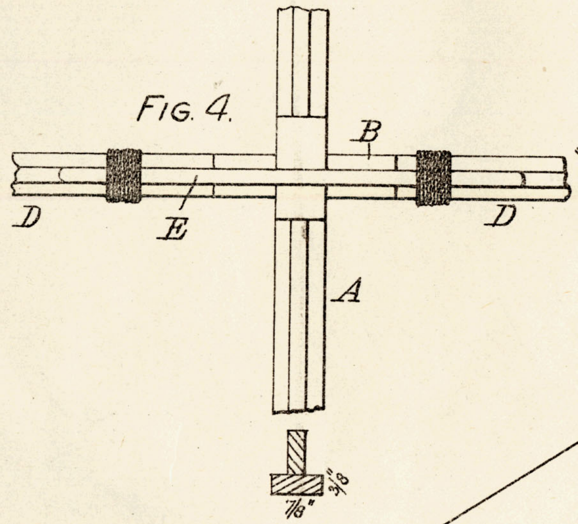

FIG. 6.

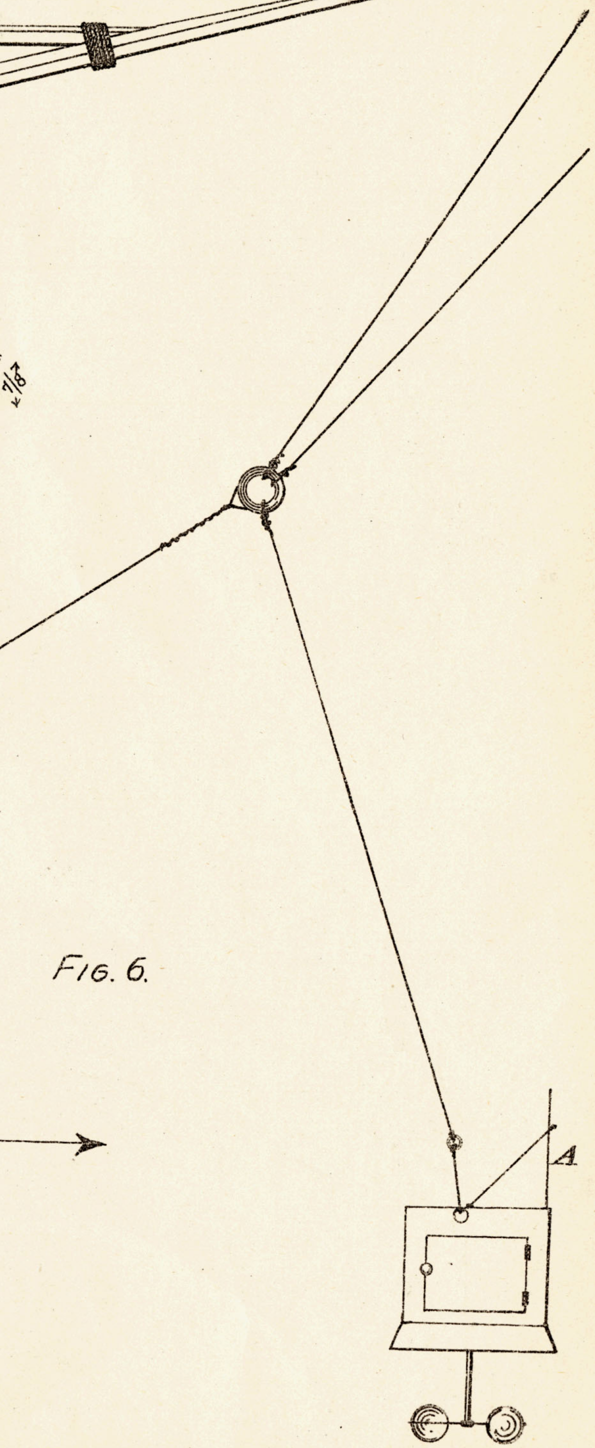

Chart VI. Record by Meteorograph during Kite Ascension of October 8, 1896, at Blue Hill Observatory.